



**Simulation Interoperability
Standards Organization**

"Simulation Interoperability & Reuse through Standards"

SpaceFOM V2: The Next Generation in Space Simulation Interoperability and How You Can Help

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Let's start from... «Questions»

- **Why SpaceFOM?**
- **Why should we trust it?**
- **Why SpaceFOM Version 2?**
- **How can you help?**



Why SpaceFOM?

Standards Matter:

- Interoperability
- Reusability
- Reduced integration costs
- Shared understanding across organizations

Open standards enable collaboration across organizations



Why SpaceFOM?

- Spaceflight is difficult, dangerous and expensive; human spaceflight even more so
- In order to mitigate some of the danger and expense, professionals in the space domain have relied, and continue to rely, on computer simulation
- Simulation is used at every level including concept, design, analysis, production, testing, training and ultimately flight
- Distributed simulation provides a base technology for segmenting these complex space systems into smaller, and usually simpler, component systems or subsystems
- Distributed simulations require common semantics for time, space, entities and execution control.





Why SpaceFOM?

- **Integrating simulations is costly**
 - Need to minimize the integration effort for new and reused systems
- **Open standards offer a more efficient way to combine and reuse systems and tools in new configurations**
 - They also offer a neutral ground that is easier to accept for many participants than proprietary interfaces
 - Open standard can also capture best-practices and help communicate them to new developers
- **HLA is not enough to ensure interoperability, a FOM is also needed; thus, the SISO Space Reference FOM (SpaceFOM)**
- **The SpaceFOM should make collaboration politically, contractually and technically easier**





Why should we trust it?

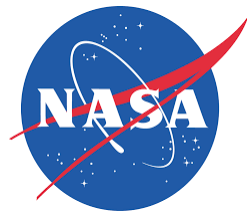
A Collaborative Success Story

Government

Industry

Academia

Working together since 2016



Brunel
University
London



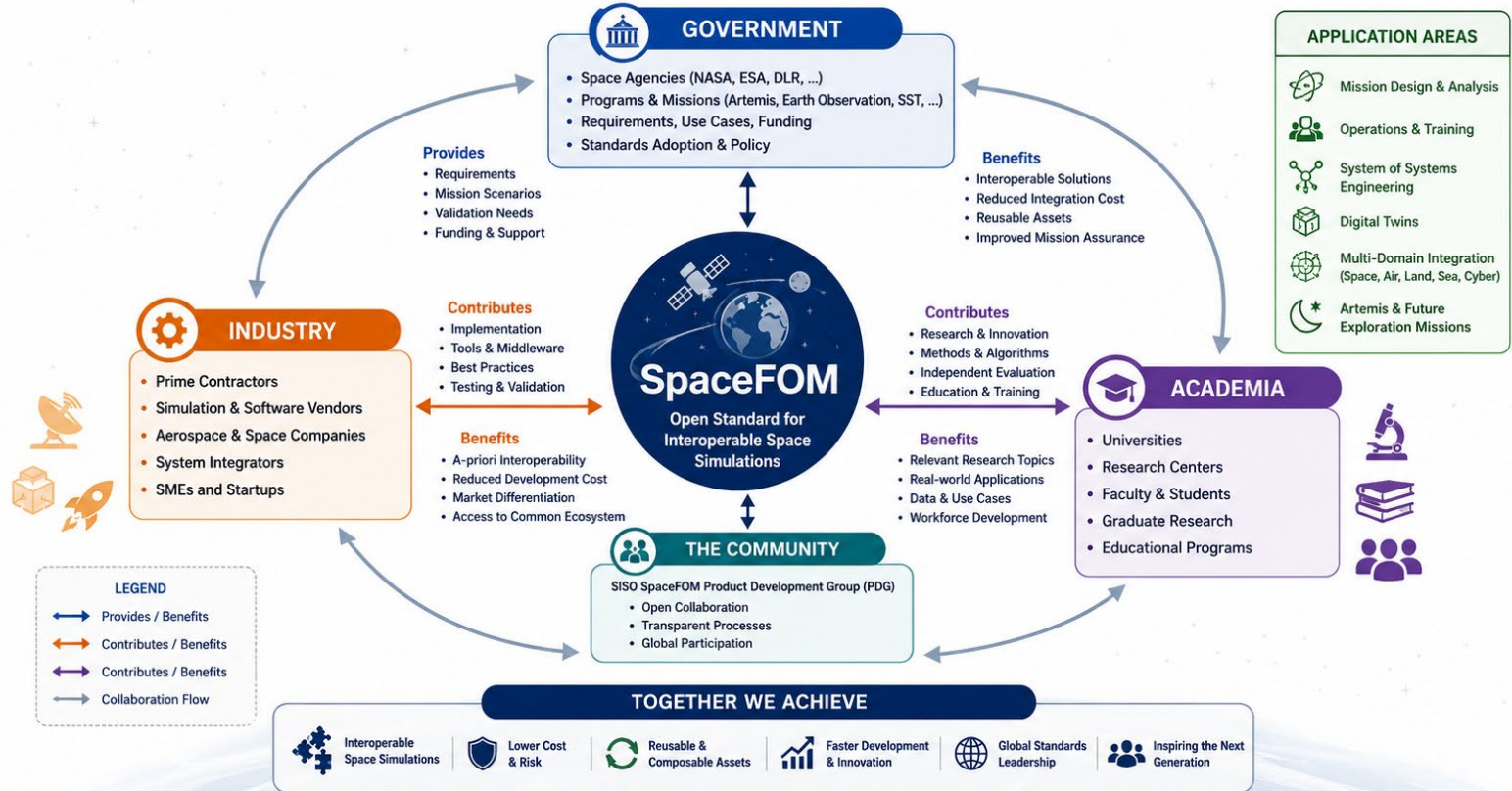
TOR VERGATA
UNIVERSITÀ DEGLI STUDI DI ROMA





The SpaceFOM Ecosystem

Government, Industry, and Academia Working Together for Interoperable Space Simulation



One Standard. Many Partners. Infinite Possibilities.

SpaceFOM – Enabling Interoperability Across the Space Enterprise.



Why should we trust it?

SpaceFOM: A Decade of Research, Development, and Adoption (2016–2026)



Key Milestones

- 2015: Space Reference FOM initiative launched
- 2020: Space Reference FOM (SISO-STD-018-2020) Released
- 2021: Journal of Simulation publication
- 2022: IEEE Aerospace and DS-RT recognition
- 2025: Artemis-related simulation activities
- 2026: Launch of SpaceFOM 2.0 PDG



Why should we trust it?

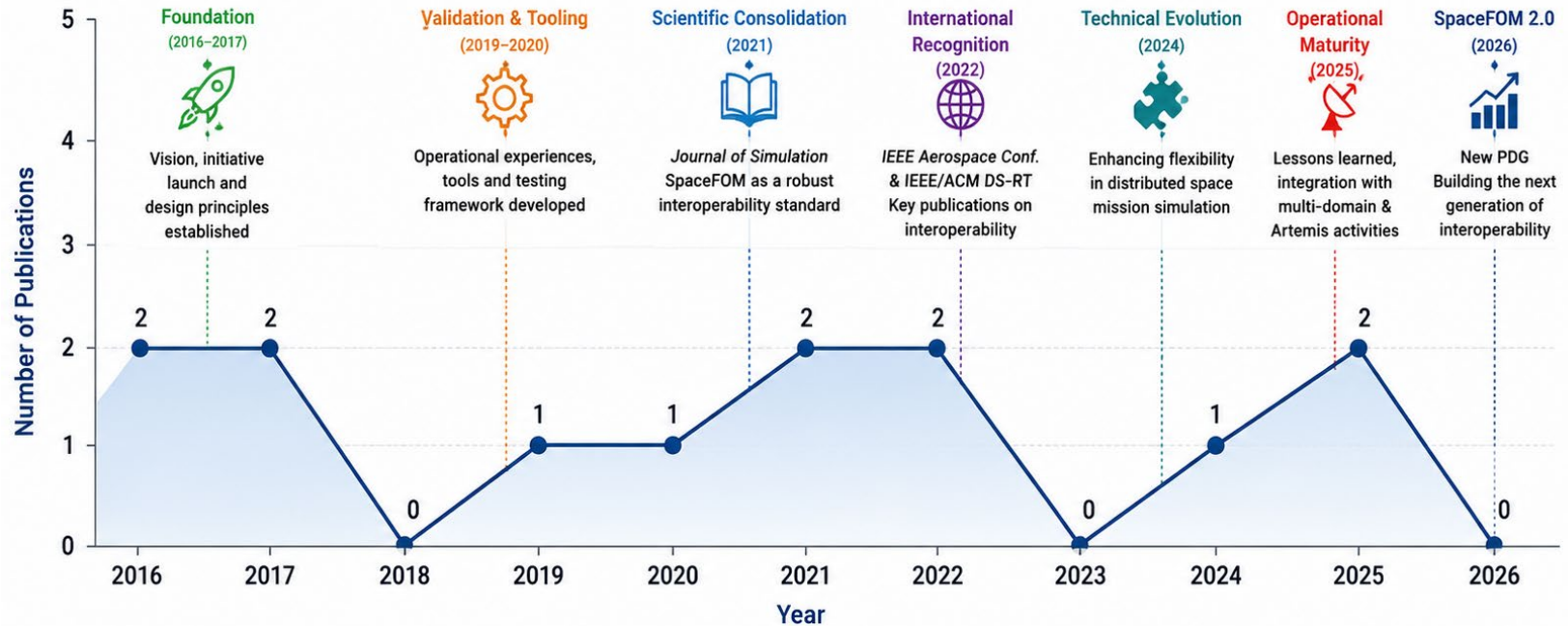
Scientific Dissemination

- Documenting 10+ years of SpaceFOM evolution
- Peer-reviewed journal articles
- IEEE Aerospace
- IEEE DS-RT (Distributed Simulation and Real Time Applications)
- SISO SIW (Simulation Innovation Workshop)
- SCS SummerSim (Summer Simulation Conference)
- Contributions from government, industry, and academia
- Support for NASA Artemis-related activities
- Foundation for SpaceFOM 2.0



Growth of SpaceFOM-related Publications (2016–2026)

Core SpaceFOM bibliography (Space Reference FOM & SpaceFOM publications)



10+ years
of continuous
research and
development



13+ core
SpaceFOM
publications



Contributions from
government, industry,
and academia



International collaborations
spanning NASA, ESA,
industry, and universities



Applied to
Artemis-related
simulation activities

Note: Counts include the core SpaceFOM bibliography items (Space Reference FOM & SpaceFOM publications).



Why should we trust it?

Impact on Government Programs

- Applications in Artemis-related studies, mission operations, and training activities

Impact on Industry

- A-priori interoperability
- Reduced integration effort
- Reusable simulation assets
- Lower risk

Impact on Academia

- Research
- Innovation
- Education (e.g. the SEE project)
- Workforce development





Why should we trust it?

- **Simulation Exploration Experience (SEE) provides international inter-university teams with hands on M&S experience with**
 - Standards & interoperability
 - Distributed HLA and SpaceFOM simulation testing and execution
 - Participation among far-flung international teams
 - Government and industry tutors and mentors

“As an experienced M&S educator, SEE allows me to give students practical and educational experience in a very complex area using a uniquely inspiring approach. There is nothing else out there that comes anywhere close to SEE.”

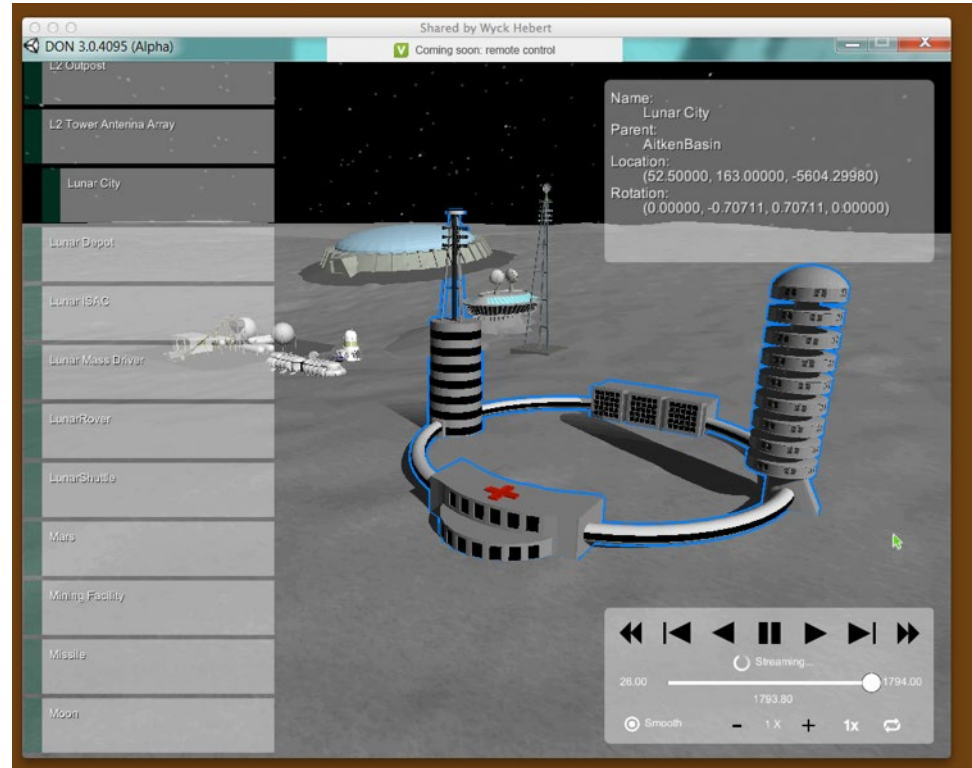
Simon Taylor, Ph.D., faculty Advisor of the Brunel University team



Why should we trust it?

Some SEE Vignettes

- Operations in Aitken Basin on the moon
- Scanning for mining resources
- Constructing a waste management facility
- Astronaut health monitoring
- Operating an asteroid protection systems
- Launching a laser thrust space craft





Why SpaceFOM Version 2?

Road Ahead...



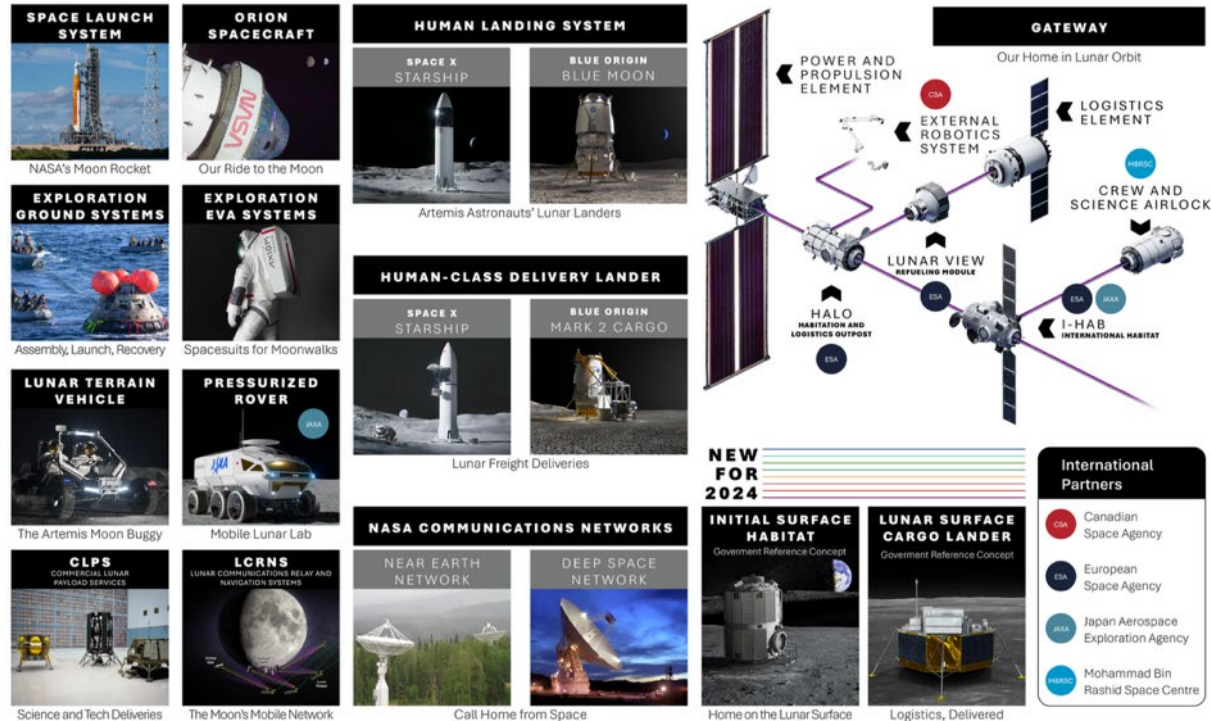
Road Ahead for SpaceFOM

- **SISO SpaceFOM 1.0 was published in 2020**
- **A Product Support Group is now in place**
 - Provide guidance and support on the FOM
 - Collect input for future SpaceFOM versions, initiate new versions
- **A number of Product Change Requests (PCRs) for the next SpaceFOM are under development**
- **Starting a Product Development Group (PDG) for SpaceFOM 2.0**



Extension of FOM classes

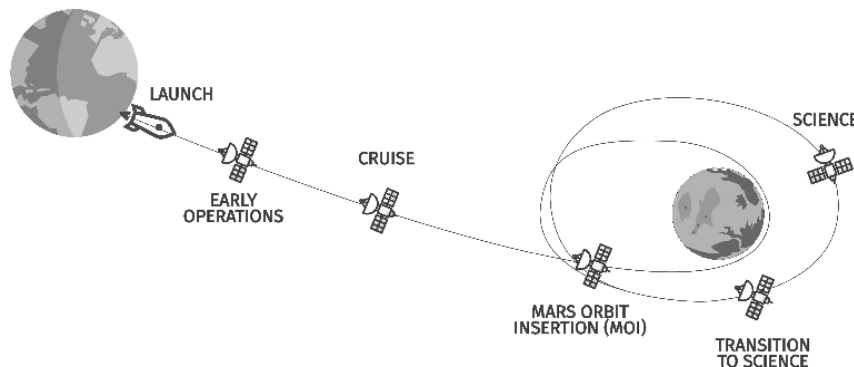
- SpaceFOM 1.0 has a very generic set of object and interaction classes
- There is now extensive experience from extending the classes from projects like NASA Artemis and European Space Agency HRAF 3.





Time and Time Resolutions

- Configurable time resolution
- Updated Epoch (2000)
- Improved time documentation in FESFA and FCD



Use case for variable time resolution

SpaceFOM 1.0 →

BASE_TIME_SECONDS	0
BASE_TIME_100_MILLISECONDS	1
BASE_TIME_10_MILLISECONDS	2
BASE_TIME_MILLISECONDS	3
BASE_TIME_100_MICROSECONDS	4
BASE_TIME_10_MICROSECONDS	5
BASE_TIME_MICROSECONDS	6
BASE_TIME_100_NANOSECONDS	7
BASE_TIME_10_NANOSECONDS	8
BASE_TIME_NANOSECONDS	9
BASE_TIME_100_PICOSECONDS	10
BASE_TIME_10_PICOSECONDS	11
BASE_TIME_PICOSECONDS	12
BASE_TIME_100_FEMTOSECONDS	13
BASE_TIME_10_FEMTOSECONDS	14
BASE_TIME_FEMTOSECONDS	15
BASE_TIME_100_ATTOSECONDS	16
BASE_TIME_10_ATTOSECONDS	17
BASE_TIME_ATTOSECONDS	18

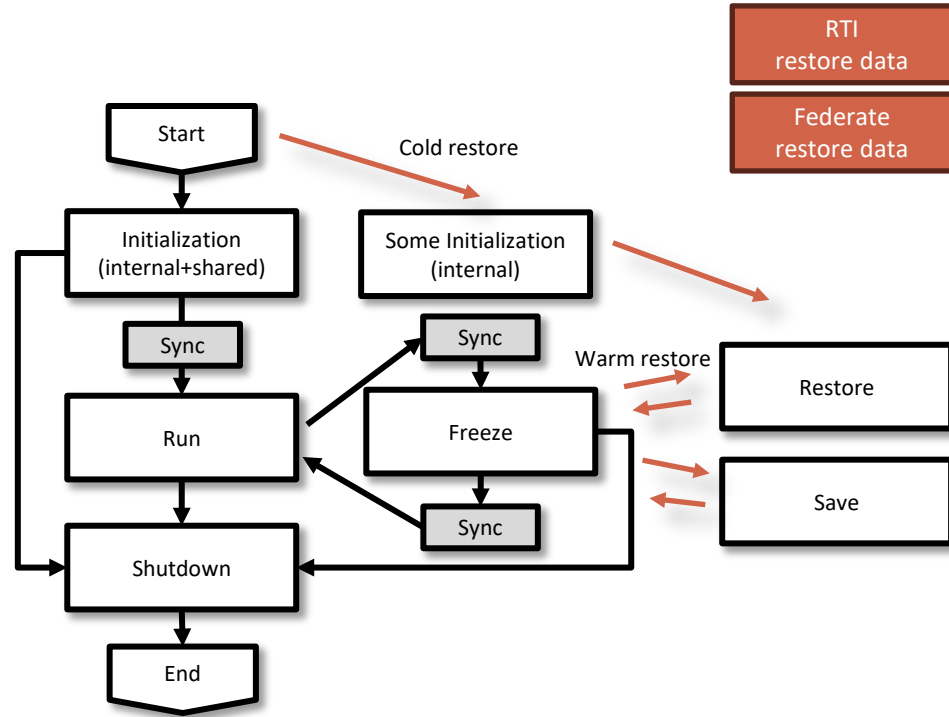
Proposed time resolutions



Save and Restore

- Restore topics

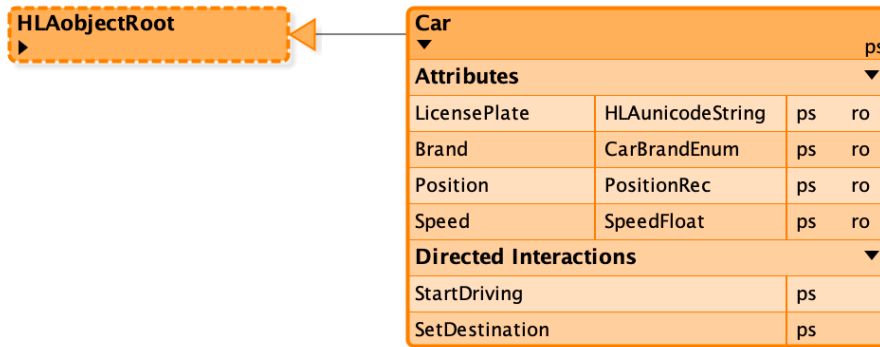
- Save in Freeze or Run state?
- Warm or Cold restore?
- Does the actual set of federates match the saved data?
- Error handling?



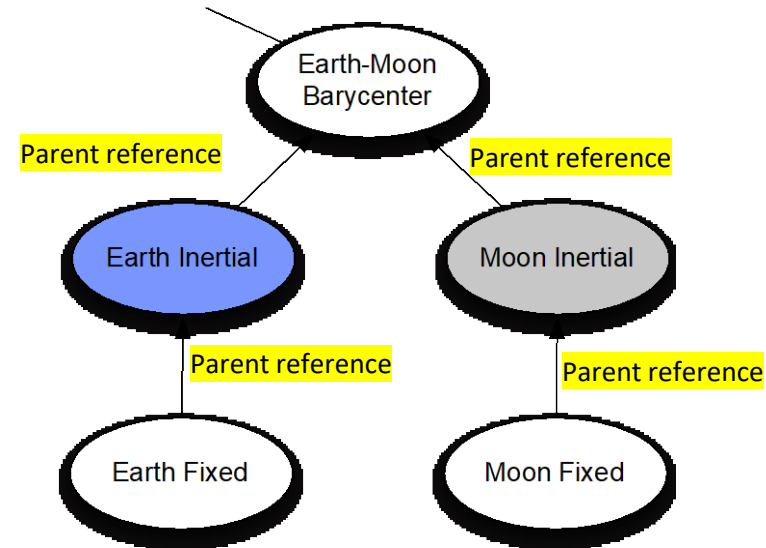


HLA 4

- Directed Interactions
- New data type: Reference



Directed Interaction use case

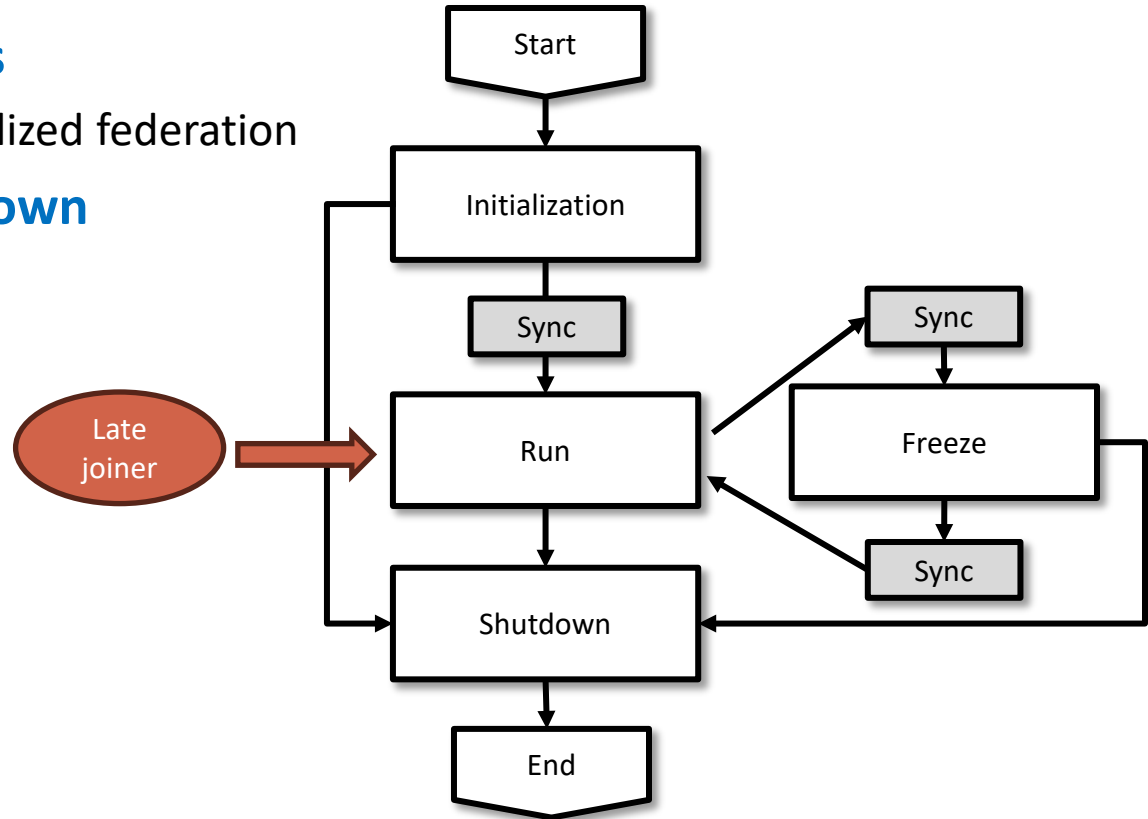


Sample SpaceFOM reference



Excution Control

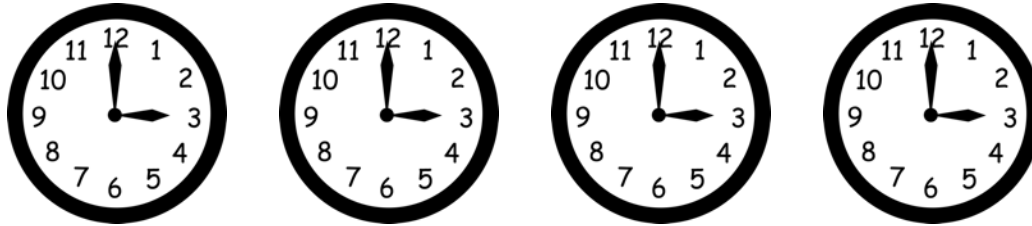
- **Designated late joiners**
 - Will always join an initialized federation
- **Fault tolerance/shut down**





Time Clarifications

- **Some minor nits**
 - Time stamps
 - TAR/TAG and time management questions





How can you help?

SpaceFOM 2.0 Opportunities:

Digital Twins

Lunar Exploration

Mars Missions

Multi-domain Interoperability



How can you help?

Bring your perspective to the next generation of space simulation interoperability.

1

Government

OPERATIONAL PERSPECTIVE

- Operational experience
- Mission requirements
- Validation
- Standards feedback

2

Industry

IMPLEMENTATION PERSPECTIVE

- New use cases
- Tools & integration
- Interoperability experience
- Product feedback

3

Academia

RESEARCH PERSPECTIVE

- Research
- Education
- Prototypes
- Student involvement

Join the SpaceFOM Product Development Group

Turn experience into the capabilities and standards the community needs next.

- Review drafts
- Propose new capabilities
- Contribute Product Change Requests (PCRs)
- Participate in working meetings
- Help shape the next generation of SpaceFOM



How can you help?

Government + Industry + Academia

Help shape the future of space simulation interoperability!!!

Thank You for your kind attention



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Simulation Interoperability Standards Organization

"Simulation Interoperability & Reuse through Standards"

QUESTIONS